AP #2

EPA-625/7-76-001

ENVIRONMENTAL POLLUTION CONTROL
PULP AND PAPER INDUSTRY
PART I
AIR

U.S. ENVIRONMENTAL PROTECTION AGENCY
Technology Transfer

October 1976

16.4.3 Liquid Scrubbers

Liquid scrubbing is used primarily for particulate collection on wood- and bark-fired power boilers in the pulp and paper industry. Scrubbing traps the particulate matter entrained in the gas stream in liquid for subsequent removal and disposal. Liquid scrubbing has the advantages of being able to remove gaseous and particulate materials simultaneously, of removing fine particles below 1 μm (4×10^{-5} in) in diameter, of recovering additional thermal energy by cooling the gas stream, and possibly of improving primary clarifier sludge settling characteristics. Vertical impingement and venturi scrubbers have been the primary types of unit employed, to date. Successful installations were reported in Montana by Effenberger (21), in Texas by Ritchey (22), and in South Carolina by Pearce (23).

Several major variables affect the design of liquid scrubbing systems for particulate emission control on wood-fired power boilers. Major gas stream variables include the overall gas flow rate, fuel firing rate, flue gas temperature and moisture content, and the allowable scrubber pressure drop as determined by fan capacity characteristics. Major particulate matter characteristics include the total particulate mass concentration and the particle size distribution, particularly for particles less than 10 μm (4×10^{-4} in) in diameter. Liquid-phase design parameters include the makeup and recycle shower rates, liquid pumping capacity, nozzle configurations and sizes, and allowable slurry solids concentrations. The physical configuration and gas-liquid contact geometry chosen are determined by the type of scrubber purchased or designed. The materials of construction, such as stainless steel, must be chosen to avoid corrosion, abrasion, and thermal damage.

The operation of a liquid scrubber is influenced primarily by the liquid phase parameters such as recycle flow rate, makeup water flow rate, nozzle liquid pressure drop, and slurry solids concentration. Gas phase pressure drop is usually subject to a certain amount of adjustment, but is also influenced by the gas flow rate as determined by fuel firing rates. The scrubbing systems described by Effenberger (21) and Ritchey (22) operate at gas pressure drops of about 15 to 25 cm (6 to 10 inches) of water and are able to achieve particulate mass concentrations at standard conditions of 0.02 to 0.05 g/m^3 (0.01 to 0.02 gr/cu ft) or less, corresponding to particulate mass removal efficiencies of 99 percent or greater. Detailed particle size measurements for these units were not provided on either inlets or outlets to the respective collectors. Liquid pH must be controlled to avoid corrosion, particularly if coal or oil is burned in combination with wood. Liquid scrubbers can prove particularly useful to upgrade the particulate collection efficiencies of existing mechanical cyclone collectors on wood-fired power boilers.

16.4.4 Fabric Filters

Fabric filters have not been extensively used for particulate collection on power boilers in the pulp and paper industry. They have the advantages of high removal efficiencies for fine

Technical Assoc. of Pulp & Paper Industry

21. Effenberger, H. K., Gradle, D. O., and Tomany, J. P., *Control of Hogged Fuel Boiler Emissions.* Tappi, 56:111-115. February 1973.

22. Ritchey, J. R., *Venturi Wet Scrubber for Particulate Control on a Bark Boiler.* In: Proceedings of the First Annual Symposium on Air Pollution Control in the Southwest. Texas A&M University, College Station, Texas. November 6, 1973.

23. Pearce, A. E., *Mechanical Dust Collection with Secondary Wet Scrubbing as Applied to a Bark Fired Power Boiler.* In: New Approaches to Particulate Collection at Bark Fired Power Boilers. National Council of the Paper Industry for Air and Stream Improvement, Inc., New York. Atmospheric Pollution Technical Bulletin No. 51, October 1970.

NWPC
2678

[illegible] C. Effenberger,
[illegible] Gradle, and James P. Tomany

Control of Hogged-Fuel Boiler Emissions

A Case History

[illegible] ons from the com- [illegible] wastes has always [illegible] a serious problem [illegible] ducts industry. In the [illegible] to about 1960, the [illegible] the acknowledged in- [illegible] the combustion of [illegible] cuttings, and bark [illegible] hogged fuel. Its low [illegible] of operation and [illegible] for an ideal solu- [illegible] nation of wood mill [illegible] the advent of atmo- [illegible] controls, some mild [illegible] to provide particu- [illegible] for the tepee [illegible] the magnitude and [illegible] gas flows and the [illegible] the burner itself [illegible] to consider the addi- [illegible] particulate collec- [illegible]

[illegible] the modern [illegible] has become an in- [illegible] hogged-fuel [illegible] production of process [illegible] of its adoption [illegible] Furthermore, [illegible] practices in- [illegible] steam and flue gas [illegible] its design, the [illegible] was adaptable to the [illegible] control equip- [illegible] for industrial [illegible]

[illegible] hogged fuel boiler [illegible] Waldorf

[illegible] and Dan D. Gradle, [illegible] Mont. [illegible] Con- [illegible] Calif.

Abstract: Simple multiple-cyclone collectors offering efficiencies in the 80–90% range no longer meet the performance demanded by the air pollution regulations. Within the past year, attention has been focused on a mechanical collector – wet scrubber system offering efficiencies of 99%+. This paper describes hogged-fuel burner processes, waste disposal problems, existing APCD regulations, available emissions control systems, and a case history of a particular cyclone – wet scrubber control system which has been in operation for over a year. With this system, final atmospheric discharge emissions in the range of 0.035–0.015 grains/dry std. ft^3 are being attained.

Keywords: Exhaust gases · Emission · Boilers · Steam generators · Hogged fuel · Wood waste · Air pollution · Scrubbers · Cyclone separators · Efficiency · Design

Corp. Missoula, Mont., mill will be described. The particulate emissions problem and the final solution comprised of a cyclone – wet scrubber control system will be discussed. Atmospheric discharge loadings and the local APCD allowable emissions will be compared.

THE PROCESS

In 1963 the mill installed a natural gas and hogged-fuel boiler. This unit was to produce process and generative steam at a maximum rate of 125,000 lb/hr, 600 psig, and 750°F. The boiler is furnished with three Peabody type H-23 tubular ring gas burners, each with a capacity of 58,000 ft^3/hr of natural gas, for a total of 174,000 ft^3/hr.

The primary fuel charged to this boiler is hogged fuel purchased from Montana lumber and saw mills. This fuel has an average moisture content of 40 wt. % and has a heating value in the range of 5300 Btu/lb (wet) and 8800 Btu/lb (dry). The fuel cost economy is most attractive, particularly as the combustion of the hogged fuel eliminates a serious disposal problem for the lumber industries.

The hogged fuel is trucked into the mill and dumped into a pit where it is transferred to a 30-in.-wide conveyor belt traveling at 388 ft/min, equivalent to a capacity of 65,000 lb/hr of hogged fuel. The fuel is conveyed to a three-compartment live bottom surge bin. Each compartment is provided with five variable speed screw conveyors which transfer the hogged fuel into the furnace injection chute. The fuel is injected into the furnace hearth by an air injector fan rated at 2600 ft^3/min. The furnace has an under–over fire combustion chamber with a porous bed for underfire fluidization of the hogged material. The forced draft fan supplies a maximum of 59,000 ft^3/min of air at 105°F to the underfire and overfire air inlets. Combustion gases leaving the economizer were discharged through the multiple cyclone type of collector

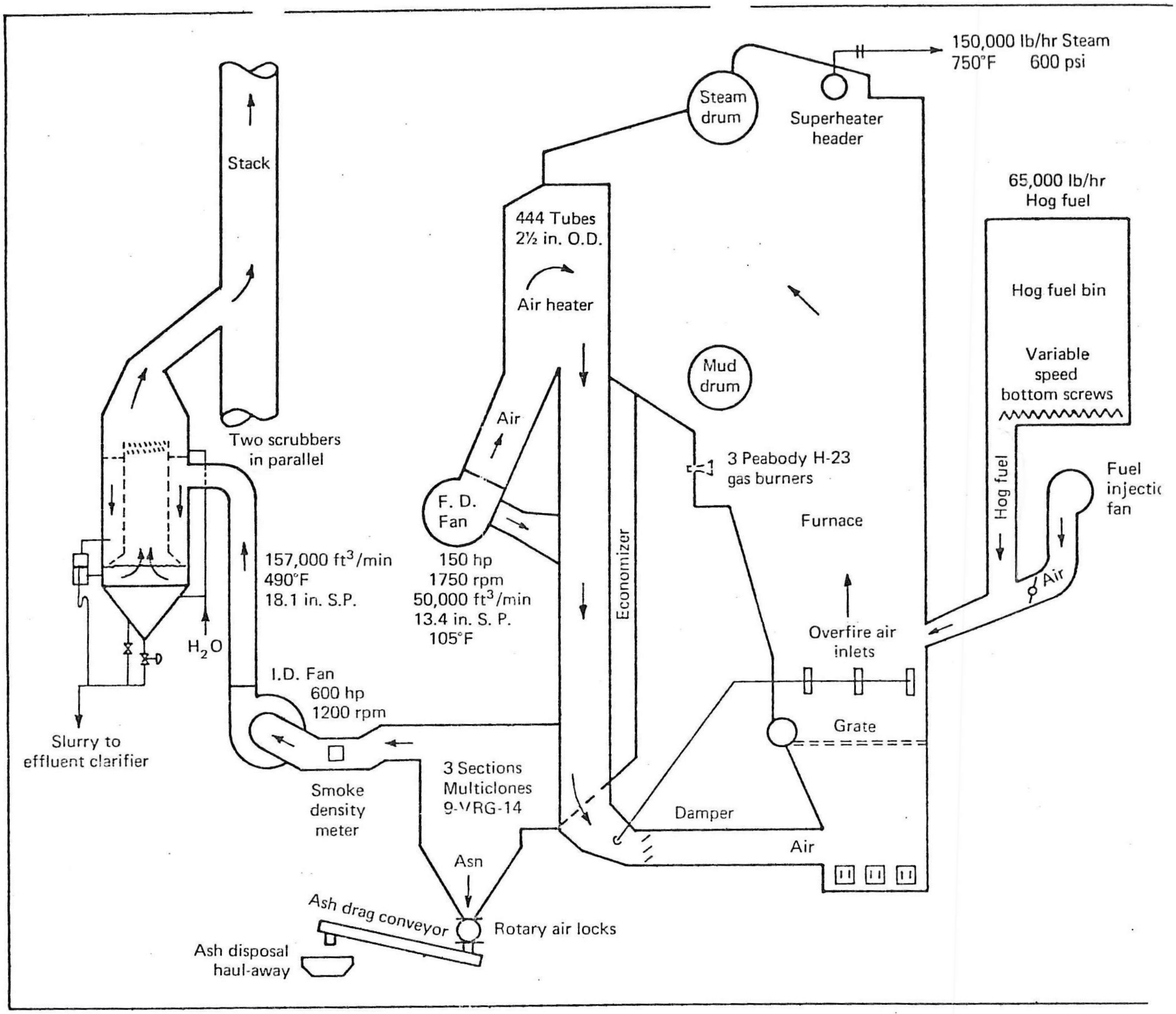

Fig. 1. Overall arrangement of furnace (Springfield boiler, installed 1963, rated 600 psi ASME).

and then to atmosphere prior to the installation of the wet scrubber. The overall arrangement of the furnace is shown in Fig. 1.

During upset periods or outages in the hogged-fuel system, natural gas is the supplemental and/or replacement fuel. At the present time, the hogged-fuel boiler is an essential element in the mill's power balance, providing an average of 125,000 to 130,000 lb/hr of 600 psig, 750°F steam for the generation of electricity, process, and mechanical equipment prime movers.

Table I. Multiclone Performance Data

Values were developed from actual measured cyclone discharge rates.

Boiler rating, lb steam/hr	150,000
Cyclone discharge gas flow, abs. ft³/min	155,100
Discharge gas temperature, °F	480–490
Multiclone collection rate, lb/hr	780
Multiclone discharge rate, lb/hr	400
Fly-ash bulk density, lb/ft³	
Dry	9.4
Wet	15.9
Multiclone inlet loading, grains/std. ft³ at 12% CO_2	2.64
Multiclone discharge loading, grains/std. ft³ at 12% CO_2	0.90
Multiclone collection efficiency, %	66.0

THE EMISSIONS PROBLEM

The emissions from hogged-fuel boilers consist of fly-ash particulates only. Both sulfur oxide and nitrogen oxide gaseous concentrations are negligible. The fly-ash is considerably different from that produced in coal firing, containing a higher proportion of carboniferous material or char than the noncombustibles comprising coal ash. The particulate emissions from the multiclones have a specific gravity of about 2.6. Approximately 85% of the pa are less than 10 μm in size. Ent with the char is a varying am sand, the quantity depending method by which the original w logged and delivered to the mill.

[illegible]itially the fly-ash emissions from [illegible] boiler were controlled by three sec[illegible] of Western Precipitation's Type [illegible]G-14 Multiclones. These collec[illegible] were arranged in parallel, dis[illegible]ing 155,100 abs. ft^3/min of 12% [illegible] flue gas at 490°F and a boiler [illegible] load of 150,000 lb/hr. Each Mul[illegible] section is provided with an ash [illegible] which is discharged through a [illegible] air lock into 9-in-diam. screw [illegible]eyors. The screw conveyors dis[illegible] the ash to a drag chain conveyor [illegible] portable buckets which are [illegible]ported to landfill disposal sites.

[illegible]sting indicated that emissions [illegible] the Multiclones were about 2.5 [illegible] per 10^6 Btu input, an unacceptable [illegible]rmance according to the "Clean [illegible] Act of Montana," which allows 0.27 [illegible] particulate emissions per 10^6 Btu [illegible] rating. Prorated performance [illegible] for the Multiclone collector is [illegible] in Table I.

[illegible]SSIONS CONTROL SYSTEM

[illegible] selection and design of an opti[illegible] emissions control system is total[illegible]pendent on the process pollutant [illegible]cteristics and the prevailing [illegible] regulations. The pollutant type, [illegible] size, and loadings were defined [illegible]sly. The emission regulations in [illegible]rthwest have recently been [illegible], the present code allowing a [illegible] loading of 0.10 grain/std. ft^3 [illegible] boiler installations and 0.15 [illegible] std. ft^3 for existing operations.

[illegible] recognized solutions for the [illegible] of hogged-fuel boiler fly-ash [illegible] have been considered. In [illegible] increasing effectiveness of per[illegible], the solutions are as follows:

[illegible] 1: Multiple Cyclone Collector

[illegible] hogged-fuel boilers are [illegible] with the multiple cyclone [illegible] centrifugal collector. In most [illegible] this solution is no longer ade[illegible] because of increasingly severe [illegible] limitations. For example, as[illegible] an inlet loading of 3 grains/std. [illegible] fly-ash particle size at 30% [illegible] 10 μm, a collection efficiency [illegible] of 75–80% could [illegible]. At an average inlet load[illegible] grains/std. ft^3, the minimum [illegible] loading would be 0.6 grain/ [illegible] which would not meet the cur[illegible] demanding emission levels [illegible] grain/std. ft.[3] Even should [illegible] size analysis run as coarse [illegible] than [illegible] μm, a collection [illegible] of about [illegible]% could be ob[illegible] with this type of collector, [illegible] to a discharge loading of [illegible] std. ft^3, still well over the [illegible]quirements.

Solution 2: Fractionating Collector

In this arrangement, a fraction of the gas stream is drawn from the top of a multiple cyclone collector hopper and is directed either through another smaller but similar type of collector or through a wet scrubber. As little as 10% of the total stream might be thus treated, and when the secondary collector is a wet scrubber, the clean saturated gas stream is recombined with that from the multiple cyclone collector to dissipate the steam plume. The final loading discharged from this combination is roughly half of that obtained with Solution 1. Therefore, at particle size analyses values of 30 and 10% less than 10 μm, collection efficiencies of 90 and 93% might be obtained, respectively. Thus, the emissions from this arrangement are quite marginal if they must meet the current codes.

Solution 3: Cyclone – Wet Scrubber

In this arrangement, a wet scrubber is located downstream of and in series with a cyclone collector. Because a considerable portion of the collected fly-ash will be discharged as a slurry, the total collection and disposal system must be considered. The fly-ash particle size going to the wet scrubber should be determined before sizing the scrubber. Overall collection efficiencies for the cyclone – wet scrubber combination of 99% can be attained. This arrangement is a good choice in the design of a hogged-fuel boiler emissions system that will "meet the code."

To bring the mill's boiler emissions into compliance with the Montana APCD regulations, it was decided to adopt Solution 3. Two Western Precipitation Type D Turbulaire scrubbers were installed to handle the Multiclone exit gases (Fig. 2). These gases are drawn into an induced-draft (ID) fan and delivered through a vertical duct to the two scrubbers arranged in parallel. Dampers on the ID fan inlet are adjusted to control the furnace draft. Gases entering the scrubber are diverted downward through a peripheral nozzle where the velocity is increased to effect their impingement into the water slurry sump. The level is maintained in this sump by the overflow weir and adjustment of the makeup water flow. The saturated clean gases reverse their flow direction, passing upward through the swirl vanes and then into the spray eliminator chamber where entrained ash and water droplets are separated from the gas stream. The separated liquor is returned to the scrubber sump via weep holes located at the periphery of the swirl vane assembly. A portion of the scrubber makeup water is added through flushing nozzle [illegible] this area to ensure uninterrupted flow through the weep holes. The saturated gases are discharged to atmosphere from each scrubber through a single stack.

The ash slurry liquor is continuously discharged from each scrubber by parallel flows through the scrubber sump discharge line and the overflow weir. The weir discharge is maintained as a trim control flow to ensure a constant level in the scrubber sump. The total slurry flow from both scrubbers is gravity discharged to a recovery sump from where it is pumped with other sewer effluents to a 200-ft-diam. Dorr Oliver clarifier. The precipitated ash is removed by sludge pumps and transferred to a sludge pond.

These scrubbers were fabricated of Type 316 stainless steel to resist both the corrosive and erosive effects of the fly-ash. However, tests of the discharged slurry indicate a pH in the range of 6.8 to 7.4. These data and over a year of operating experience with the scrubbers would indicate that mild steel construction would be suitable for future installations.

OPERATING RESULTS

Gases are discharged from the cyclones at temperatures of 480–490°F with dust loadings in the range of 0.47 to 1.47 grain/dry std. ft^3 at 12% CO_2. The wet scrubber discharge gases were at temperatures of 130–147°F and contained fly-ash loadings in the range of 0.028 to 0.047 grain/dry std. ft^3 corrected to 12% CO_2 (Table II). These values were determined with a sampling train comprised of a stainless steel probe, air condenser, two water impingers, thimble, glass fiber filter, gas meter, and vacuum pump. The sequence of the impingers, thimble, and glass fiber filters was varied in the train with the thimbles being favored for dry gas dust collection and the impingers – glass filter combination collecting the gas-borne dust escaping the wet scrubbers.

Because of the variation in the cyclone discharge dust loadings, 0.47–1.47 grain/std. ft^3, equivalent to 0.15–0.46 grain/abs. ft^3, it was decided to rate the scrubber performance at an inlet loading of 70% of the span or 0.365 grain/abs. ft^3. The scrubber performance was determined at two pressure drop values, 7.5 in. w.g. and 8.5 in. w.g. Collection efficiencies of 96.7 and 98.3% were obtained, respectively, at these two pressure drop values for the rated boiler capacity (Table III). These efficiency values are equivalent to emission rates of 0.085 and 0.043 lb/10^6 Btu. They are based on a heat input to the hogged-fuel boiler generating 150,000 lb steam/hr and approximately 4.3 lb steam per pound of

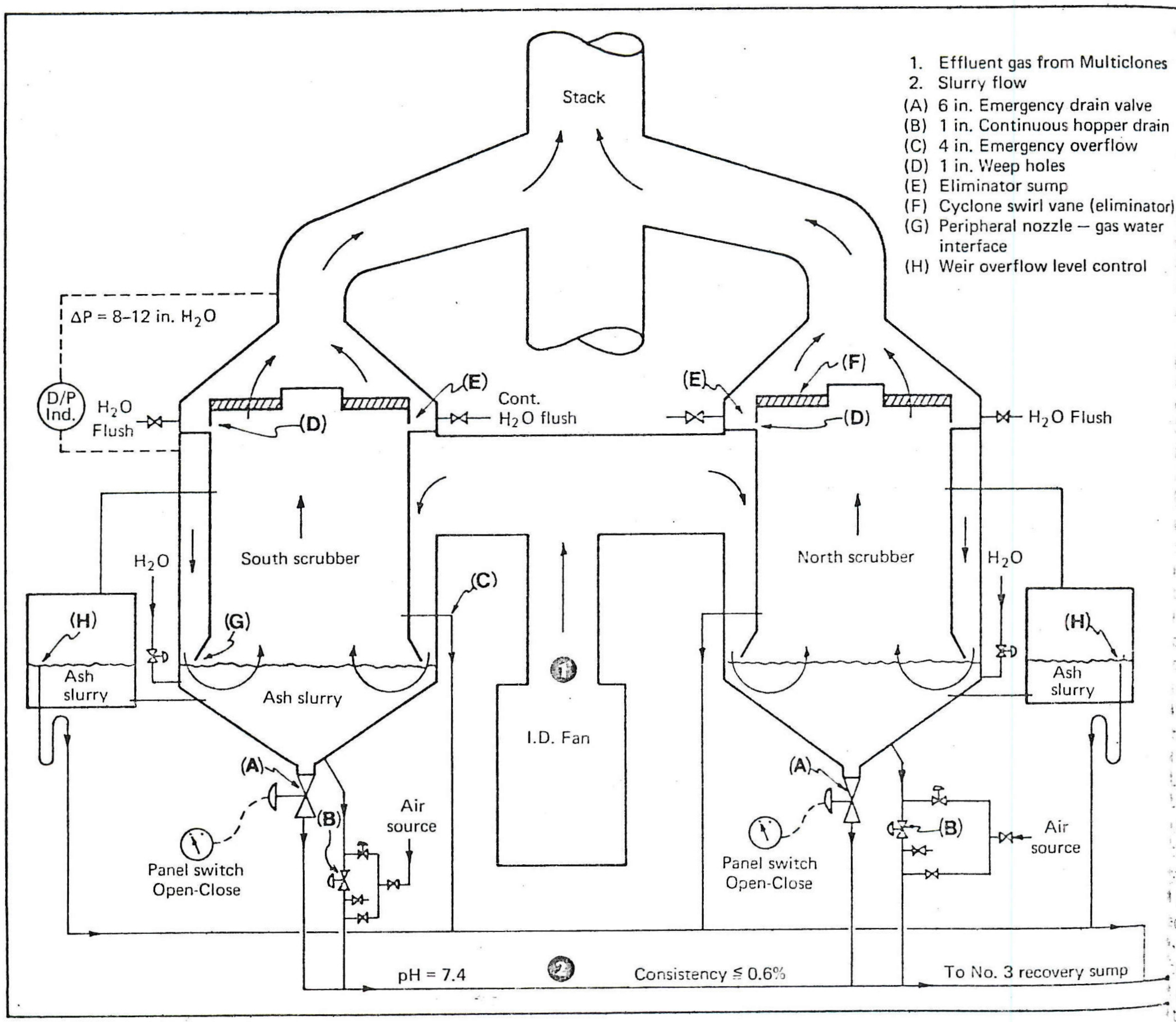

Fig. 2. Arrangement of scrubbers.

Table II. Multiclone and Wet Scrubber Particulate Test Results—Hogged Fuel Boiler Emissions Control

								Loadings	
Run No.	*Date*	*Discharge location*	*Boiler load, lb/hr steam*	*Gas fuel firing*	*Flue gas flow, abs. ft^3/min*	*Flue gas temp., °F*	*Moisture, vol. %*	*Grain/abs. ft^3*	*Grain/dry std. ft^3*
1	3/23/71	Multiclone	140,000	Yes	158,000	425	14.5	0.18	0.42
2	3/23/71	Multiclone	140,000	Yes	158,000	425	14.3	0.15	0.34
3	3/24/71	Wet scrubber	140,000	Yes	110,000	163	20.6	0.016	0.029
4	3/24/71	Wet scrubber	140,000	Yes	110,000	163	18.6	0.012	0.020
5	3/25/71	Wet scrubber	105,000	No	113,000	162	23.6	0.019	0.035
6	3/25/71	Multiclone	108,000	No	167,000	442	15.2	0.46	1.08

Table III. Wet Scrubber Performance Test Results—Hogged-Fuel Boiler Emission Control

Boiler load, lb/hr steam	Gas flow, abs. ft³/min	Gas temp., °F	Moisture, vol. %	Press. drop, in. w.g.	Stack emissions: Grain/abs. ft³[a]	Grain/dry std. ft³	lb/hr	lb/10⁶ Btu[b]	Coll. eff'y,[c] %	State Standard lb/10⁶ Btu
150,000	108,200	147	25.0	7.5	0.0173	0.0320	16.1	0.085	96.7	0.27
150,000	110,200	146	27.2	8.5	0.0085	0.0157	8.1	0.043	98.3	0.27

[a] Grain dry std. ft³ at 32°F, 29.92 in. Hg and approximately 8.5% CO_2 in flue gas.
[b] Based on a boiler heat input of 5320 Btu/lb of wet hogged fuel and 4.2 lb steam per lb of wet hogged fuel.
[c] Efficiencies based on average inlet loading of 0.365 grain/abs. ft³.

hogged fuel, wet, having an approximate heat value of 5320 Btu/lb, wet. These values lie well below the Montana State requirement of 0.27 lb of particulates per 10⁶ Btu boiler input.

The Turbulaire scrubber was designed to maintain a guaranteed collection efficiency at a fixed pressure drop for a specific particle size distribution. The performance guarantee for the installation described here was specified at [illegible]% at a 5-in. w.g. pressure drop. The pressure drop is determined by a calculated gap setting for the peripheral nozzle based on a specified saturated gas flow and by maintaining the sump liquid level ½ in. below the edge of the peripheral nozzle. Actually, the sump liquid level was varied by adjustment of the overflow weir. By increasing the weir extension, the liquor level was increased in the scrubber and the overall pressure drop across the peripheral nozzle increased as well. By such adjustments, the operating pressure drop was varied within the range of 6.0 to [illegible] in. w.g., and as would be expected, the emissions decreased proportionately. The correlation is shown in Tables III and IV. The results reflect the expected increase in particulate emissions at advancing boiler steam loads.

The makeup water requirements to each scrubber is that necessary to saturate the gases and provide slurry water for the fly-ash discharge, or a total of about 70 gal/min per scrubber. The evaporation rate is estimated at about [illegible] gal/min per scrubber and the slurry flow at 22 gal/min per scrubber. The slurry consistency averages 0.6% solids, moisture-free basis.

Table IV. Wet Scrubber Particulate Emissions—Hogged Fuel Boiler Emissions Control

Boiler load, lb/hr steam	Stack conditions: Gas flow, abs. ft³/min	Gas temp., °F	Press. drop in. w.g.	Stack emissions: Grain/abs. ft³[a]	Grain/dry std. ft³	lb/hr	Allowable emissions,[b] lb/hr
Weir extension = zero							
80,000	79,200	132	6.0	0.0034	0.0063	2.32	46.4
100,000	84,500	137	6.2	0.0053	0.0089	3.85	56.0
135,000	97,900	142	. . .	0.0043	0.0077	3.62	70.6
155,000	105,800	142	6.5	0.0135	0.0239	12.20	78.2
Weir extension = 0.5 in.							
80,000	77,900	131	6.0	0.0037	0.0059	2.46	46.4
100,000	86,100	136	6.6	0.0048	0.0080	3.53	56.0
135,000	93,600	142	6.9	0.0089	0.0158	7.13	70.6
150,000	101,100	141	7.1	0.0086	0.0152	7.45	76.7
Weir extension = 1.0 in.							
80,000	77,900	132	6.0	0.0025	0.0041	1.67	46.4
100,000	76,200	137	7.6	0.0044	0.0076	2.90	56.0
130,000	101,400	140	7.5	0.0047	0.0084	4.04	68.0
135,000	101,400	140	7.7	0.0048	0.0084	4.10	70.6
150,000	100,800	143	7.7	0.0086	0.0154	7.44	76.7

[a] Grain/dry std. ft³ at 32°F, 29.92 in. Hg and approximately 8.5% CO_2 in flue gas.
[b] Allowable emissions based on Montana State regulation 90-006.

CONCLUSIONS

The conclusions to be drawn from the mill's experiences in the control of hogged-fuel boiler emissions are as follows:

1. A maximum collection efficiency of [illegible]% was obtained with the scrubber only at a pressure drop of 8.5 in.

2. An overall maximum collection efficiency of the Multiclone collector plus Turbulaire wet scrubber is estimated at 99%+.

3. The fly-ash discharge loadings during tests ranged from 0.015 to 0.035 grain/dry std. ft³, equivalent to emission rates of 0.040–0.091 lb/10⁶ Btu. These values are well below the prevailing Montana State requirement of 0.27 lb per 10⁶ Btu at a steam load of 150,000 lb/hr.

4. These discharge loading rates are believed to be well below any future regulation that might be anticipated. It is estimated to be well within the Ringelmann No. 1 reading.

5. Additional regulation of the Turbulaire wet scrubber collection efficiency can be effected by varying the pressure drop across the scrubber. For a pressure drop increase of 6.5–7.7 in. w.g., a corresponding decrease in discharge loadings from 0.0239 to 0.0154 grain/dry std. ft³ was recorded at a steam load of 150,000 lb/hr.

6. Burning sawdust and smaller particles of hogged-fuel will present a higher load to the wet scrubber and may require operation at a higher pressure drop across the unit.

7. Maintenance problems consist of occasional cleaning of the scrubber inlet nozzle.

In view of the successful operation of the cyclone - wet scrubber arrangement, other companies have been encouraged to install a similar system to handle the effluent from their hogged-fuel boiler. It should be mentioned that this method of emissions control has the disadvantage of a visible steam plume above the stack, the need for a continuous supply of water to the scrubbers and for the disposal of the ash slurry from the scrubbers.

Received for review June 1, 1972.
Accepted July 11, 1972.
Presented at the Environmental Conference of the Technical Association of the Pulp and Paper Industry, held in Houston, Texas, May 14-18, 1972.

NWPC
2678

ZURN INDUSTRIES, INC.

Air Systems Div.
Birmingham, AL

Wet Scrubbers on Wood Waste Fired Boilers

Installation Data

CUSTOMER	LOCATION & SHIP.DATE	PROCESS CAPACITY #/Hr.Steam	APPLICATION	SAT. VOL. & TEMP. ACFM °F	VENTURI, SEPARATOR & MATERIAL	ΔP Inches W.G.	PERFORMANCE GR/SCFD Inlet	PERFORMANCE GR/SCFD Outlet
Oxford Paper FC 715	Rumford, ME 4-72	170,000	Bark (Secondary Shave Off)	20,000 133	Horizontal Cyclonic C.S.	8		
Southland Paper FD 560	Lufkin, TX 3-73	110,000	Bark & Natural Gas	77,000 159	Two (2) Horizontal Cyclonic C.S.	11-12	N/A	.004 (
Champion Paper FD 722	Canton, N.C. 4-73	160,000	Bark, Oil & Coal	110,250 131	Race Track Cyclonic 316 L S.S.	10		.1
ITT Rayonier FE 678	Jesup, GA 3-74	112,000	Bark & Oil (30% Secondary Shave Off)	20,000	Race Track Cyclonic 316 L S.S.	10	1.0	.0328
Albemarle Paper Co. FE 756	Roanoke Rapids, NC 8-74	Pilot Test	Bark & Oil	4,000	Horizontal Cyclonic C.S.	13	4.6	.02 (T
Robert Mallery Lumber FE 1196	Emporium, PA 10-74	19,000	Wood Waste	13,650 149	Horizontal Cyclonic C.S.	6	N/A	.049 (
Georgia Pacific FE 1010	Cross City, FL 11-74	40,000	Wood Waste	25,300 154	Vertical Cyclonic C.S.	6		.055 (T

RECEIVED DEC 3 197

ZURN INDUSTRIES, INC.
Air Systems Div.
Birmingham, AL

Wet Scrubbers on Wood Waste Fired Boilers

Installation Data

CUSTOMER	LOCATION & SHIP.DATE	PROCESS CAPACITY #/Hr.Steam	APPLICATION	SAT. VOL. & TEMP. ACFM °F	VENTURI, SEPARATOR & MATERIAL	ΔP Inches W.G.	PERFORMANCE GR/SCFD Inlet	PERFORMANCE GR/SCFD Outlet
Westvaco FE ?84	Charleston, SC 11-74	70,000	Bark & Oil	33,800 160	Race Track Cyclonic 316 L. S.S.	10		.055 (
Willamette Industries FF 252	Dodson, LA 12-74	80,000	Wood Waste	40,000 145	Horizontal Cyclonic C.S.	6	.5	.02 (TV
Southwest Forest Ind. FF 622	Eager, AZ 2-75	25,000	Wood Waste	18,000 140	Horizontal Cyclonic C.S.	4		
Talisman Sugar FF 792	Belle Glade, FL 8-75	190,000	Bagasse & Oil	146,000 154	Vertical Cyclonic 316 L S.S.	10	1.0	0.043 (
Georgia Pacific Corp. FF 928	Prosperity, S.C. 10-75	80,000	Wood Waste	40,000 145	Horizontal Cyclonic C.S.	7	.3	
Olin Kraft FK 418	Monroe, LA 1-76	165,000	Bark & Natural Gas	110,000 147	Race Track 316 L S.S. Cyclonic C.S.	8	N/A	.0265
Interstate Paper FH 823	Riceboro, GA 7-76	60,000	Wood Waste	40,000 156	Race Track Cyclonic 316 L S.S.	3	1.0	

RECEIVED DEC 3 19

Z U R N I N D U S T R I E S , I N C .

Air Systems Div.
Birmingham, AL

Wet Scrubbers on Wood Waste Fired Boilers

Installation Data

CUSTOMER	LOCATION & SHIP.DATE	PROCESS CAPACITY #/Hr.Steam	APPLICATION	SAT. VOL. & TEMP. ACFM °F	VENTURI, SEPARATOR & MATERIAL	ΔP Inches W.G.	PERFORMANCE GR/SCFD Inlet	Outlet
Greensboro Lumber FG 8	Greensboro, GA 1-77	75,000	Wood Waste	40,000 145	Vertical Cyclonic C.S.	6	.5	.05
Bennett Lumber FJ-118	Princeton, ID 7-77	60,000	Wood Waste	42,500 145	Horizontal Cyclonic C.S.	4	0.2	.05
Chespeake Corp. FH 888	West Point, VA 7-77	100,000	Wood Waste & Oil	74,700 162	Racetrack Cyclonic 316 L S.S.	10	N/A	.05
Hampom Lumber FH 954	Redding, CA 7-77	40,000	Wood Waste	17,700 148	Vertical Cyclonic C.S.	6	.75	
Georgia Pacific FJ 627	Peterman, AL 2-78	140,000	Hogged Fuel	79,280 147	Horizontal Cyclonic C.S.	6	1.0	0.08 (
Cowlitz Stud FJ 780	Morten, WA 3-78	30,000	Wood Waste	24,000 147	Vertical Cyclonic C.S.	30		
Hercules FH 875	Brunswick, GA 2-78	200,000	Wood Waste	97,800	Race Track Incoloy 825 Cyclonic 316 L S.S	12	1.71	.043

ZURN INDUSTRIES, INC.
Air Systems Div.
Birmingham, AL
Wet Scrubbers on Wood Waste Fired Boilers
Installation Data

CUSTOMER	LOCATION & SHIP.DATE	PROCESS CAPACITY #/Hr.Steam	APPLICATION	SAT. VOL. & TEMP. ACFM °F	VENTURI, SEPARATOR & MATERIAL	ΔP Inches W.G.	PERFORMANCE GR/SCFD Inlet	PERFORMANCE GR/SCFD Outlet
Louisiana Pacific FJ [illegible]4	Jasper, TX 4-78	80,000	Wood Waste	52,200 146	Horizontal Cyclonic C.S.	6	.5	0.05
Louisiana Pacific FJ 635	Crestview, FL 4-78	80,000	Wood Waste	52,200 146	Horizontal Cyclonic C.S.	6	.5	0.05
Bates Lumber FJ 863	Albuquerque, NM 5-78	20,000	Wood Waste	11,800	Vertical Cyclonic C.S.	6		
Boise Southern FK [illegible]43	De Quincey, LA 7-78	45,000	Wood Waste	25,000 148	Horizontal Cyclonic C.S.	6	1.0	.3
Cowlitz Stud FK 219	Randle, WA 7-78	30,000	Hogged Fuel	21,000 140	Vertical Cyclonic C.S.	30	.5	
Georgia Pacific Corp. FK 205	Monticello, GA 7-78	120,000	Wood Waste	82,500 151	Race Track Cyclonic C.S.	6		.08 (T[illegible]
Louisiana Pacific FJ 851	Urania, LA 7-78	110,000	Wood Waste	67,000 146	Horizontal Cyclonic C.S.	4	.5	.05

ZURN INDUSTRIES, INC.

Air Systems Div.

Birmingham, AL

Wet Scrubbers on Wood Waste Fired Boilers

Installation Data

CUSTOMER	LOCATION & SHIP. DATE	PROCESS CAPACITY #/Hr. Steam	APPLICATION	SAT. VOL. & TEMP. ACFM °F	VENTURI, SEPARATOR & MATERIAL	ΔP Inches W.G.	PERFORMANCE GR/SCFD Inlet	PERFORMANCE GR/SCFD Outlet
Georgia Pacific Corp. FK [illegible]4	Durand, GA 8-78	120,000	Wood Waste	82,000 151	Race Track Cyclonic C.S.	6		
Louisiana Pacific FK 183	Lufkin, TX 9-78	120,000	Wood Waste	74,000 145	Horizontal Cyclonic C.S.	6	0.5	.035
International Paper FK 596	Eatonton, GA 12-78	40,000	Wood Waste	31,000 145	Horizontal Cyclonic C.S.	3 - 4	.9 (TV)	.09
Gilman Paper FK [illegible]31	St. Mary's, GA 3-79	180.000	Wood Waste	145,000 150	Race Track Cyclonic 316 L S.S.	10	.5	.05
Mead Corp. FK 459	Stevenson, AL 1-79	200,000	Wood Waste	121,000 145	Two - Horizontal Cyclonic C.S.	10	.5	0.03
Georgia Pacific Corp. FK 182	Dudley, N.C. 3-79	165,000	Wood Waste	100,000 143	Two - Horizontal Cyclonic C.S.	4	5	0,1
Foster Wheeler for Publisher's Paper	Newburg, OR 9-79	300,000	Wood Waste	200,000	Center Cone SpinVane 316L	13	1,8	0.036

RECEIVED DEC 3 1979

U.S.E.P.A.
REGION 9
COMM CNTR

Reply to: Seattle

DEC 18 10 04 AM '79

NSR 4-4-1
NC 79-67

NWPC

NOR'WEST-PACIFIC CORPORATION

December 14, 1979

Environmental Protection Agency
Region 9
215 Fremont
San Francisco, California 94105

NWPC 2678

Subject: New Hog-fuel Boiler, Air Pollution Discharge Permit
Georgia-Pacific Corp., Ft. Bragg, California

Attention: Mr. Donald Harvey, Environmental Engineer and Mr. Ray Sied

Gentlemen:

This letter is our response to the discussion regarding the subject permit application at the meeting of December 3, 1979, in your offices. In addition to yourselves, the meeting was attended by Ralph Shoulders, Keith Bentley of Georgia-Pacific and by Donald Pingrey and Norm Waggoner of NWPC.

As a result of the discussion, we have researched for additional, supportive data and therefore, we believe that we have better information to substantiate our selections of categories of air pollution controls. We are, therefore, now requesting that you please make the determination on the acceptability of a venturi wet scrubber and/or a wet ESP for the particulate control on the subject proposal.

Based on the test data we have been able to locate, some of which was earlier submitted to you, an outlet particulate loading of .035-.036 gr/DSCF (@ 12% CO_2) can be achieved by wet venturi scrubbers operating at 6-8 inches of water, static pressure. We know that these numbers are not quite as low as the .03 gr/DSCF which we want to achieve in order to stay below the 50 tons/year emission rate. But the manufacturers of the venturi-type scrubbers say that they can guarantee the limit of .03 or better if the pressure is raised to the range of 10-12 inches of water, and they are reliable and reputable companies. Since our client is willing to operate a wet venturi-scrubber at this higher pressure, we feel it is only fair to give serious consideration to this system as a reasonable and acceptable means for achieving the specified grain loading limit.

We have already spent a considerable amount of time attempting to obtain data on stack tests indicating emission control to .03 gr/DSCF or below. One of the problems has been that most of the hog fuel boilers tested used oil or natural gas as a supplementary fuel. We recognize that this combined fuel combustion may "dilute" the scrubber inlet particulate concentration and thus provide for a somewhat reduced outlet concentration. The difficulty has been to find test data on boilers that use absolutely no supplementary oil or natural gas for presentation to you.

Another source of information is the data from pilot tests, some of which have used wet ESP units attaining levels of control well below the .03 gr/DSCF limit. We hope that you will not reject this data as inapplicable. In this regard, it should be noted that the wet ESP is a more recent innovation, and there is less data available for it; we have been unable to find any performance test data for a wet ESP controlling a boiler which burns <u>only</u> hog fuel. Thus, if the data from pilot tests is ruled unacceptable, then we feel the wet ESP is being judged as inadequate without a sufficient examination.

The wet ESP manufacturers, which are also reputable companies, have stated that they can guarantee their units at or below a limit of .03 gr/DSCF when used to control hog fuel boiler emissions past the primary, mechanical collector. The companies we have been in contact with are shown below.

<u>WET ELECTROSTATIC PRECIPITATORS</u>

<u>Wet ESP Vendor</u>	<u>Sales Engineer</u>
Fluid-Ionic Systems, a division of Envirotech Corp.	Ned Lund (206) 671-1336 Bellingham, Washington
Air Pollution Systems, Inc.	Jim Schwab (206) 251-5330 Kent, Washington

We have re-contracted suppliers of venturi scrubbers for strictly compliance-type, source test data showing that their units can meet the specified limit. The manufacturers we've discussed this with are listed below.

<u>WET VENTURI SCRUBBERS</u>

Riley Stoker Co.	Bob Childs (503) 244-7567 Portland, Oregon
Zurn Industries (Tate-Reynolds, Inc.)	Keith Anderson (206) 455-9911 Bellevue, Washington

WET VENTURI SCRUBBERS (continued)

Western Precipitation — Don Reger (213) 240-2300, Los Angeles, California

Andersen 2000, Inc. — Jack Brady (404) 997-2000, Atlanta, Georgia

They tell us that it is a difficult process to obtain source test results from their clients, as it is generally considered confidential, and they regard this as a strange request. These suppliers represent large companies which are willing to stand on their reputations and guarantee the .03 gr/DSCF limit; they think that should be sufficient. On the basis of prior experience with these suppliers, we are inclined to agree.

As final evidence that the guarantee for a wet scrubber to meet the desired limit is both reasonable and adequate, we are enclosing a copy of an EPA publication, dated October 1976. It states that particulate emission limits of .01 to .02 gr/SCF from hog fuel boilers have been achieved by wet scrubbers operating at pressure drops from 6 to 10 inches of water. Three reference sources are listed as substantiation, one of which (Effenberger) is enclosed for your review.

We have spent as much time researching this subject as we feel will be productive. We have obtained and submitted performance test data for the Riley "Ventri-Rod", venturi scrubber showing particulate limits to .036 gr/DSCF at low pressure and pilot test data showing limits below .03 at a medium pressure drop. We've submitted a Georgia-Pacific report which shows the performance test results at Fort Bragg on two wood-fired boilers controlled by Bumstead-Woolford, low pressure scrubbers, both of which meet the .03 gr/DSCF limit. We are also enclosing data on Zurn Industries' wet scrubber emission controls; and, we are sending an EPA document stating that .01 to .02 gr/SCF is readily achievable at medium pressure with a wet scrubber. We have even obtained promises of guarantees from all of the listed suppliers of both venturi wet scrubbers and wet ESP's that the .03 gr/DSCF limit can and will be met.

We don't want to go into a PSD determination in order to receive the permit for the boiler and have accordingly reduced the design capacity to discharge less than 50 tons/year of particulate at .032 gr/DSCF. We want you to examine the data we have submitted and accept the fact that .03 gr/DSCF can be attained either by a venturi wet scrubber or a wet ESP. Attempting to obtain the construction permit has delayed the project for almost a year. At the present rate of inflation this continuing delay is costly to the job and may lead to a termination of the project. We need a serious consideration at this time and acceptance of the information we have provided.

We ask that you give our data and other evidence an honest evaluation, and we request that you issue a permit for the boiler. Please let us know if you have any further questions.

Very truly yours,

Donald W. Pingrey

DONALD W. PINGREY

DWP/fp

Enclosures (4)

DEMONSTRATION OF A HIGH FIELD ELECTROSTATICALLY ENHANCED VENTURI SCRUBBER ON A MAGNESIUM FURNACE FUME EMISSION

by

M. T. Kearns
Air Pollution Systems, Inc.
Kent, Washington 98031

and

D. L. Harmon
Industrial Environmental Research Laboratory
U.S. Environmental Protection Agency
Research Triangle Park,
North Carolina 27711

ABSTRACT

A 566m^3/m (20,000 acfm) permanent installation demonstration system, consisting of the Air Pollution Systems' High Intensity Ionizer and a variable throat venturi scrubber (called the Scrub-E) has been installed on a magnesium recovery furnace. The furnace produces submicron fume particles of MgO, $MgCl_2$ and $ZrCl_4$. The system is designed to demonstrate the effectiveness of the High Intensity Ionizer versus high venturi pressure drop on the furnace emissions. The High Intensity Ionizer array operates stably at field strengths of 10-15 kV/cm and at velocities in excess of 18m/s (60 fps) while maintaining high charging efficiencies. The report covers the system design, technology, applications, and project developments. An Environmental Protection Agency proposed charged droplet Scrub-E is also discussed covering the design, technology, and proposed demonstration program.

RECEIVED NOV 2 8 1979

DEMONSTRATION OF A HIGH FIELD ELECTROSTATICALLY ENHANCED VENTURI SCRUBBER ON A MAGNESIUM FURNACE FUME EMISSION

INTRODUCTION

The Particulate Technology Branch of the U.S. Environmental Protection Agency (IERL-RTP) has had for the last 5 years the responsibility to evaluate and bring to commercial feasibility, devices based on new collection principles or concepts, or new combinations of existing concepts. An emphasis has been placed on those devices that are applicable to the metallurgical industry, and that can be easily retrofitted to existing equipment. In 1977, the EPA issued a competetive procurement to "...demonstrate at pilot or small full scale the technical and economic feasibility for the most promising existing novel particulate collection system for control of fine particulate emissions from industrial sources." This competetive procurement was won by Air Pollution Systems, Inc. (APS) to demonstrate the Scrub-E which was tested in the APS laboratory under the novel device evaluation program. A contract was funded in September 1977 with APS to demonstrate the Scrub-E on a fine particulate source ($\leq$ 3μm in diameter). A magnesium recovery furnace which emits submicron particles of MgO, $MgCl_2$, and $ZrCl_4$ was selected as the demonstration site. The Scrub-E is currently erected (July 1979) with startup to occur within the next few months. (See Figure 1.)

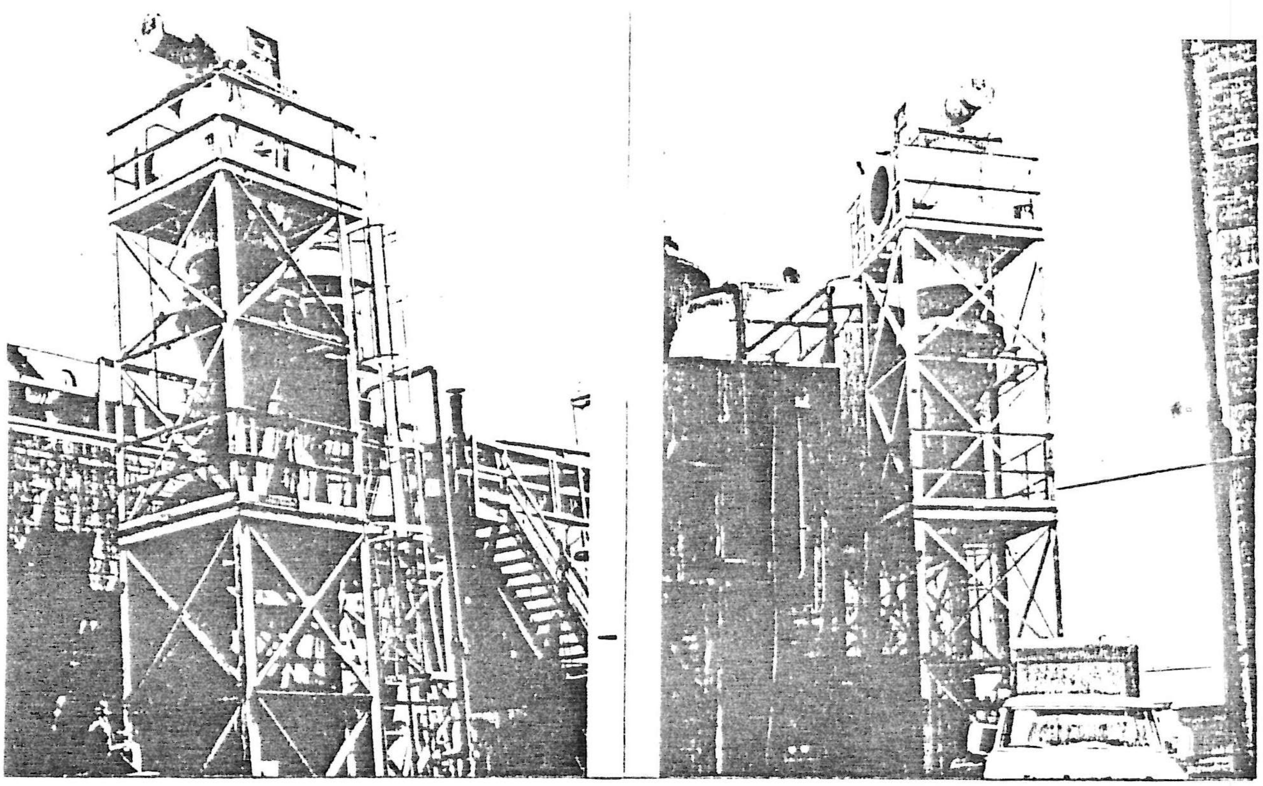

Figure 1. EPA Scrub-E demonstration system.

BACKGROUND

Substantiated research has concluded that fine particulate ($\leq$ 3μm in diameter) can result in serious environmental and health problems. The impact of fine particulates on visibility and cloud nucleation is compounded by their extremely low settling rate (mobility) and resultant persistence in the atmosphere. The above factors are compounded if the fine particulate is composed of toxic substances. This has caused increased control requirements to be set by the air pollution control agencies.

The collection of fine particulate is presently limited to equipment which is either very large and/or has high operating costs. The choices include equipment such as precipitators and baghouses which are large and have a high capital cost, or venturi scrubbers which are relatively cheap, but require very high energy consumption to collect fine particulate. The users of fine particle collection equipment are, therefore, faced with capital and/or operating costs which are becoming prohibitive, especially in the case of the venturi scrubber.

APS has taken the venturi scrubber system which represents the smallest and consequently the cheapest capital cost and attempted to reduce the operating costs to a reasonable level. The resultant system, the Scrub-E, incorporates the APS High Intensity Ionizer with the venturi scrubber system. (See Figure 2).

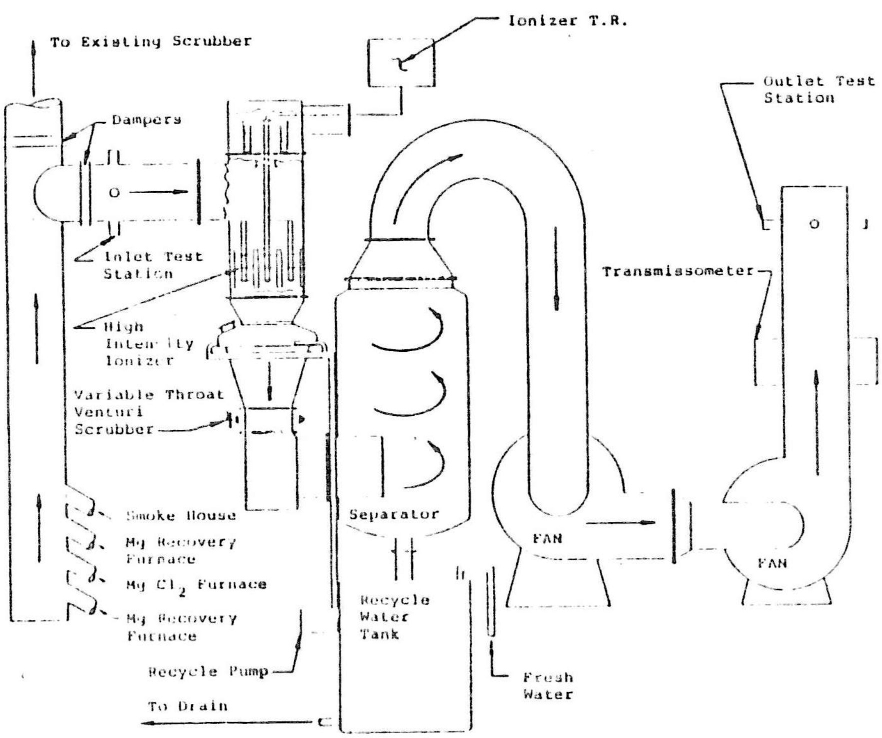

Figure 2. EPA demonstration system schematic flow diagram.

The Scrub-E utilizes the combination of electrostatic forces and inertial forces for the removal of particulate. This combination maintains an improved efficiency on fine particulate while requiring one-half to two-thirds the energy consumption of a conventional scrubber (see Figure 3). The design of the ionizing unit provides for a relatively small add-on device to precharge the particulate.

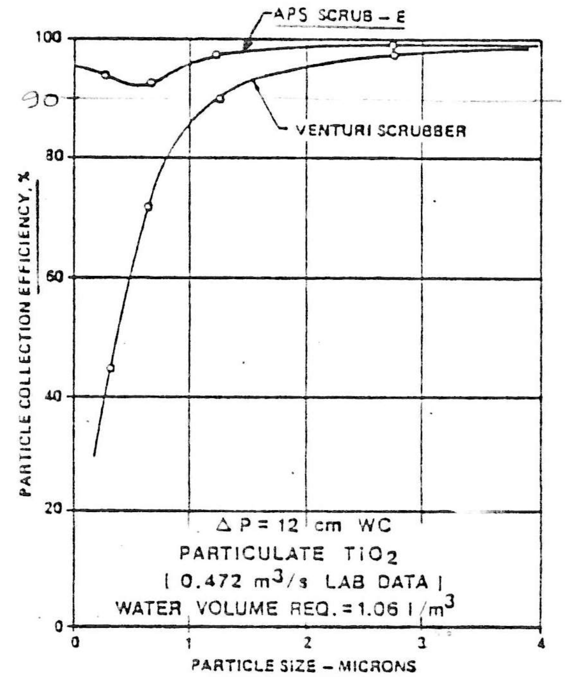

Figure 3. Particle removal efficiency.

FUNDAMENTAL THEORY

Particle Charging

From classical theory, the amount of charge collected by a particle in an electric field depends on the strength of the field, the density of charge present as ions (or in some cases electrons), the particle radius and dielectric qualities of its constituent material, and the amount of time available for charging. This is defined by Oglesby et al.[1] as follows:

the saturation charge on particles due to field charging

$$q_s = 12(\varepsilon/\varepsilon+2)\pi\varepsilon_o a^2 E_o \quad (1)$$

where ε = relative dielectric constant

ε_o = permittivity of free space

$= 8.85 \times 10^{-12}$ farads/m

a = particle radius, meters

E_o = electric field v/m